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# Geometric Design Tables

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## A. General

The following sections present two sets of design criteria tables - Preferred Roadway Elements (Table 5C-1.01) and Acceptable Roadway Elements (Table 5C-1.02). In general, the “Preferred” table summarizes design values taken from the AASHTO’s “Green Book” that may be considered “preferred” while the “Acceptable” table represents AASHTO minimums or practical minimums not covered in AASHTO.

Designers should strive to provide a design that meets or exceeds the criteria established in the “Preferred” table. For designs where this is not practical, values between the “Preferred” and “Acceptable” tables may be utilized, with approval of the Engineer.

The Federal Highway Administration has modified some of the controlling geometric design criteria for projects on the National Highway System (NHS). These changes were based on an analysis of the 13 controlling criteria reported in NCHRP Report 783 and are incorporated in 23 CFR 625. The changes include reducing the number of criteria to 10 by eliminating bridge width, vertical alignment, and horizontal clearance since those elements were covered under another criteria or they were found not to have significant operational or safety impacts. For lower speed facilities with a design speed of less than 50 mph, the controlling criteria only includes design speed and structural capacity.

However, since all projects on the NHS, regardless of funding source, must meet the design guidelines in the [Iowa DOT Design Manual](#), which includes the FHWA criteria, SUDAS has not modified the geometric design criteria contained herein that is used for locally funded and non-NHS Federal-Aid projects.

## B. Design Controls and Criteria

The selection of various values for roadway design elements is dependent upon three general design criteria: functional classification, design speed, and adjacent land use.

- 1. Functional Classification:** The first step in establishing design criteria for a roadway is to define the function that the roadway will serve (refer to [Section 5B-1](#) for street classifications). The functional classification of the roadway is the basis for the cross-sectional design criteria shown in Tables 5C-1.01 and 5C-1.02. It also serves as the basis for the ultimate selection of design speed and geometric criteria.

Under a functional classification system, design criteria and level of service vary according to the intended function of the roadway system. Arterials are expected to provide a high level of mobility for longer trip length; therefore, they should provide a higher design speed and level of service. Since access to abutting property is not their main function, some degree of access control is desirable to enhance mobility. Collectors serve the dual function of accommodating shorter trips and providing access to abutting property. Thus, an intermediate design speed and level of service is important. Local streets serve relatively short trip lengths and function primarily for property access; therefore, there is little need for mobility or high operating speeds. This function is reflected by use of lower design speeds and an intermediate level of service.

2. **Design Speed:** Design speed is the selected speed used to determine various geometric features of the roadway, including horizontal and vertical alignment. The design speed selected should be as high as practical to attain the desired degree of safety, mobility, and efficiency. It is preferred to select a design speed that is at least 5 mph greater than the anticipated posted speed limit of the roadway. Selecting a design speed equal to the posted speed limit may also be acceptable and should be evaluated on a project by project basis, subject to approval of the Engineer. Once the design speed is selected, all pertinent roadway features should be related to it to obtain a balanced design.

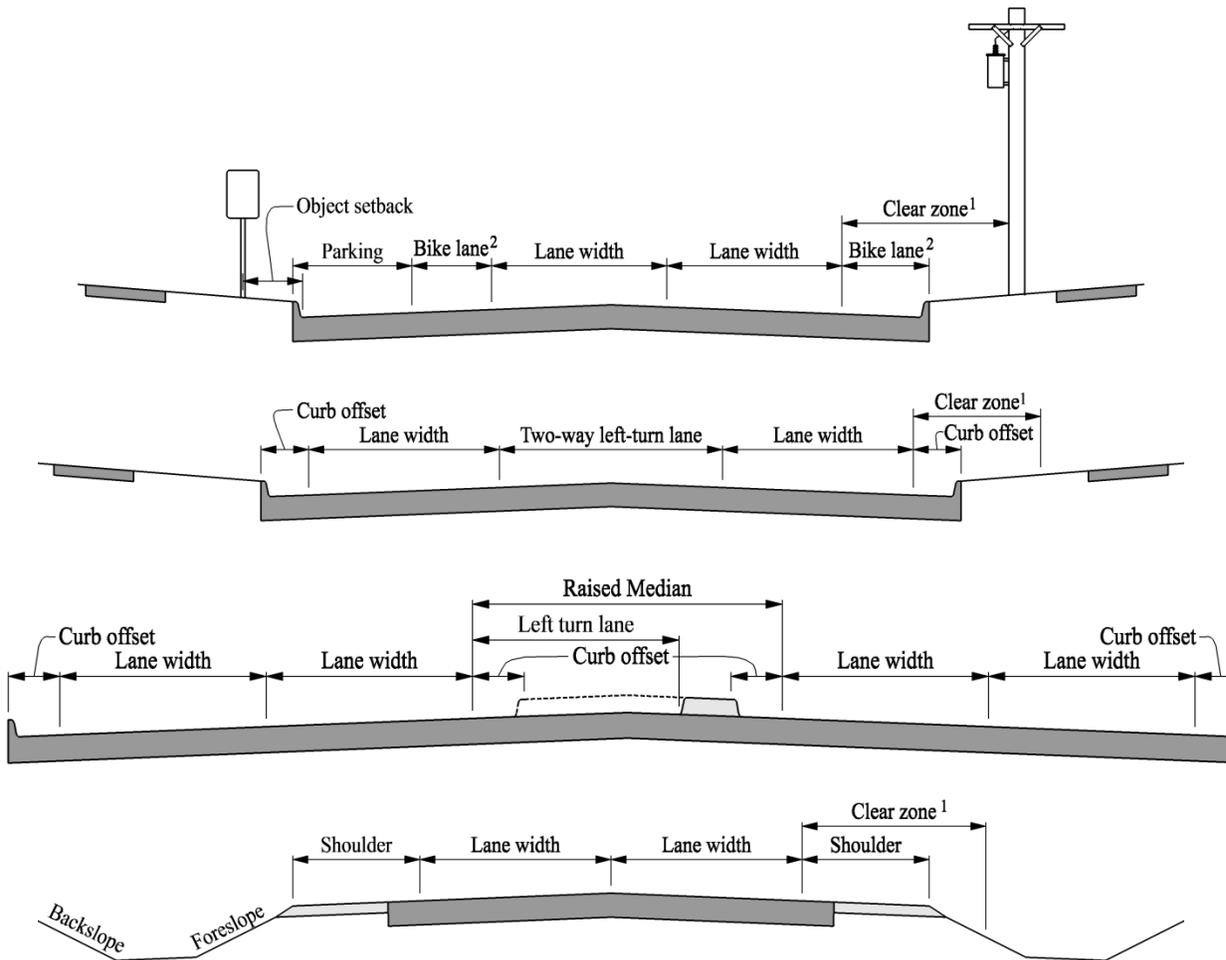
In some situations, it may be impractical to conform with the desired design speed for all elements of the roadway (e.g. horizontal radius or clear zone). In these situations, warning signs or additional safety treatments may be required (e.g. warning signs or guard rail).

3. **Adjacent Land Use:** In addition to functional classification and design speed, the surrounding land use can impact the design elements of the roadway corridor as well. Land use can be categorized into three groups: residential, commercial, and industrial.
  - a. Residential areas are regions defined by residential or multi-family zoning districts where single-family houses, apartment buildings, condominium complexes and townhome developments are located. Because these facilities typically have lower overall traffic volumes, low truck volumes, and are utilized primarily by drivers who are familiar with the roadway, some design values can be set at a lower level than for commercial or industrial areas.
  - b. Commercial and industrial areas are highly developed regions generally defined by commercial and industrial zoning districts where factories, office buildings, strip malls, and shopping centers are or will be located. The areas typically require higher level design values due to increased traffic volumes, increased truck volumes, and decreased driver familiarity.

### C. Roadway Design Tables

The following figures illustrate the location of various design elements of the roadway cross-section as specified in Tables 5C-1.01 and 5C-1.02.

**Figure 5C-1.01: Roadway Design Elements**



<sup>1</sup> Clear zone is measured from the edge of the traveled way.

<sup>2</sup> See [Chapter 12](#) for bike lane requirements.

**Table 5C-1.01: Preferred Roadway Elements**  
Elements Related to Functional Classification

Design Element	Local		Collector		Arterial	
	Res.	C/I	Res.	C/I	Res.	C/I
<b>General</b>						
Design level of service <sup>1</sup>	D	D	C/D	C/D	C/D	C/D
Lane width (single lane) (ft) <sup>2</sup>	10.5	12	12	12	12	12
Two-way left-turn lanes (TWLTL) (ft)	N/A	N/A	14	14	14	14
Width of new bridges (ft) <sup>3</sup>	See Footnote 3					
Width of bridges to remain in place (ft) <sup>4</sup>	-----	-----	-----	-----	-----	-----
Vertical clearance (ft) <sup>5</sup>	14.5	14.5	14.5	14.5	16.5	16.5
Object setback (ft) <sup>6</sup>	3	3	3	3	3	3
Clear zone (ft)	Refer to Table 5C-1.03, Table 5C-1.04, and 5C-1, C, 1					
<b>Urban</b>						
Curb offset (ft) <sup>7</sup>	2	2	2	3	3	3
Parking lane width (ft)	8	8	8	10	N/A	N/A
Roadway width with parking on one side <sup>8</sup>	26/31 <sup>9</sup>	34	34	37	N/A	N/A
Roadway width without parking <sup>10</sup>	26	31	31	31	31	31
Raised median with left-turn lane (ft) <sup>11</sup>	N/A	N/A	19.5	20.5	20.5	20.5
Cul-de-sac radius (ft)	45	45	N/A	N/A	N/A	N/A
<b>Rural Sections in Urban Areas</b>						
Shoulder width (ft)						
ADT: under 400	4	4	6	6	10	10
ADT: 400 to 1,500	6	6	6	6	10	10
ADT: 1,500 to 2000	8	8	8	8	10	10
ADT: above 2,000	8	8	8	8	10	10
Foreslope (H:V)	4:1	4:1	4:1	4:1	6:1	6:1
Backslope (H:V)	4:1	4:1	4:1	4:1	4:1	4:1

Res. = Residential, C/I = Commercial/Industrial

#### Elements Related to Design Speed

Design Element	Design Speed, mph <sup>12</sup>							
	25	30	35	40	45	50	55	60
Stopping sight distance (ft)	155	200	250	305	360	425	495	570
Passing sight distance (ft)	900	1090	1,280	1,470	1,625	1,835	1,985	2,135
Min. horizontal curve radius (ft) <sup>13</sup>	198	333	510	762	1,039	926	1,190	1,500
Min. vertical curve length (ft)	50	75	105	120	135	150	165	180
Min. rate of vertical curvature, Crest (K) <sup>14</sup>	18	30	47	71	98	136	185	245
Min. rate of vertical curvature, Sag (K)	26	37	49	64	79	96	115	136
Minimum gradient (percent)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Maximum gradient (percent)	5	5	5	5	5	5	5	5

Note: For federal-aid projects, documentation must be provided to explain why the preferred values are not being met. For non-federal aid projects, the designer must contact the Jurisdiction to determine what level of documentation, if any, is required prior to utilizing design values between the "Preferred" and "Acceptable" tables.

Table 5C-1.01 Footnotes:

- <sup>1</sup> Number of traffic lanes, turn lanes, intersection configuration, etc. should be designed to provide the overall specified LOS at the design year ADT. Two LOS values are shown for collectors and arterials. The first indicates the minimum overall LOS for the roadway as a whole; the second is the minimum LOS for individual movements at intersections.
- <sup>2</sup> Width shown is for through lanes and turn lanes.
- <sup>3</sup> Bridge width is measured as the clear width between curbs or railings. Minimum bridge width is based upon the width of the traveled way (lane widths) plus 4 feet clearance on each side; but no less than the curb-face to curb-face width of the approaching roadway. Minimum bridge widths do not include medians, turn lanes, parking, or sidewalks. At least one sidewalk should be extended across the bridge.
- <sup>4</sup> See Table 5C-1.02, for acceptable values for width of bridges to remain in place.
- <sup>5</sup> Vertical clearance includes a 0.5 foot allowance for future resurfacing.
- <sup>6</sup> Object setback does not apply to mailboxes constructed and installed according to US Postal Service regulations, including breakaway supports.
- <sup>7</sup> Values shown are measured from the edge of the traveled way to the back of curb. Curb offset is not required for turn lanes. On roadways with an anticipated posted speed of 45 mph or greater, mountable curbs are required. For pavements with gutterline jointing, the curb offset should be equal to or greater than the distance between the back of curb and longitudinal gutterline joint.
- <sup>8</sup> Parking is allowed along one side of local or collector streets unless restricted by the Jurisdiction. Some jurisdictions allow parking on both sides of the street. When this occurs, each jurisdiction will set their own standards to allow for proper clearances, including passage of large emergency vehicles. Parking is normally not allowed along arterial roadways.
- <sup>9</sup> For local, low volume residential streets, two free flowing lanes are not required and a 26 foot or 31 foot (back to back) roadway may be used where parking is allowed on one side or both sides respectively. For higher volume residential streets, which require two continuously free flowing traffic lanes, a 31 foot or 37 foot roadway should be used for one sided or two sided parking respectively.
- <sup>10</sup> Some minimum roadway widths have been increased to match standard roadway widths. Unless approved by the Jurisdiction, all two lane roadways must comply with standard widths of 26, 31, 34, or 37 feet.
- <sup>11</sup> Median width is measured between the edges of the traveled way of the inside lanes and includes the curb offset on each side of the median. Values include a left turn lane with a 6 foot raised median as required to accommodate a pedestrian access route (refer to [Chapter 12](#)) through the median (crosswalk cut through). At locations where a crosswalk does not cut through the median, the widths shown can be reduced by 2 feet to provide a 4 foot raised median.
- <sup>12</sup> It is preferred to select a design speed that is at least 5 mph greater than the anticipated posted speed limit of the roadway. Selecting a design speed equal to the posted speed limit may also be acceptable and should be evaluated on a project by project basis, subject to approval of the Engineer.
- <sup>13</sup> Values for low design speed (<50 mph) assume no removal of crown (i.e. negative 2% superelevation on outside of curve). Radii for design speeds of 50 mph or greater are based upon a superelevation rate of 4%. For radii corresponding to other superelevation rates, refer to the AASHTO's "Green Book."
- <sup>14</sup> Assumes stopping sight distance with 6 inch object.

**Table 5C-1.02: Acceptable Roadway Elements**  
Elements Related to Functional Classification

Design Element	Local		Collector		Arterial	
	Res.	C/I	Res.	C/I	Res.	C/I
<b>General</b>						
Design Level-of-Service <sup>1</sup>	D	D	D/E	D/E	D/E	D/E
Lane width (single lane) (ft) <sup>2</sup>	10	11	11	11	11	11
Two-Way Left-Turn Lanes (TWLTL) (ft)	N/A	N/A	12	12	12	12
Width of new bridges, (ft) <sup>3</sup>	See Footnote 3					
Width of bridges to remain in place (ft) <sup>4</sup>	20	22	24	24	26	26
Vertical clearance (ft) <sup>5</sup>	14.5	14.5	14.5	14.5	14.5	14.5
Object setback (ft) <sup>6</sup>	1.5	1.5	1.5	1.5	1.5	1.5
Clear zone (ft)	Refer to Table 5C-1.03, Table 5C-1.04, and 5C-1, C, 1					
<b>Urban</b>						
Curb offset (ft) <sup>7</sup>	1.5 <sup>8</sup>	1.5 <sup>8</sup>	1.5 <sup>8</sup>	1.5 <sup>8</sup>	2	2
Parking lane width (ft)	7.5	7.5	7.5	9	10	10
Roadway width with parking <sup>9, 11</sup>	26/31 <sup>10</sup>	31	31	34 <sup>11</sup>	34	34
Roadway width without parking <sup>11</sup>	26 <sup>10</sup>	26	26	26	26	26
Raised median with left-turn lane (ft) <sup>12</sup>	N/A	N/A	18	18	18.5	18.5
Cul-de-sac radius (ft)	45	45	N/A	N/A	N/A	N/A
<b>Rural Sections in Urban Areas</b>						
Shoulder width (ft)						
ADT: under 400	2	2	2	2	8	8
ADT: 400 to 1,500	5	5	5	5	8	8
ADT: 1,500 to 2,000	6	6	6	6	8	8
ADT: over 2,000	8	8	8	8	8	8
Foreslope (H:V) <sup>13</sup>	3:1	3:1	3:1	3:1	4:1	4:1
Backslope (H:V)	3:1	3:1	3:1	3:1	3:1	3:1

Res. = Residential, C/I = Commercial/Industrial

Elements Related to Design Speed

Design Element	Design Speed, mph <sup>14</sup>															
	25		30		35		40		45		50		55		60	
Stopping sight distance (ft)	155	200	250	305	360	425	495	570								
Passing sight distance (ft)	900	1,090	1,280	1,470	1,625	1,835	1,985	2,135								
Min. horizontal curve radius (ft) <sup>15</sup>	198	333	510	762	1,039	833	1,060	1,330								
Min. vertical curve length (ft)	50	75	105	120	135	150	165	180								
Min. rate of vert. curve, Crest (K) <sup>16</sup>	12	19	29	44	61	84	114	151								
Min. rate of vert. curve, Sag (K)	26	37	49	64	79	96	115	136								
Min. rate of vert. curve, Sag (K) based on driver comfort/overhead lighting <sup>17</sup>	14	20	27	35	44	54	66	78								
Minimum gradient (percent) <sup>18</sup>	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5								
Maximum gradient (percent) <sup>19</sup>	R	C/I	R	C/I	R	C/I	R	C/I	R	C/I	R	C/I	R	C/I	R	C/I
Local	12	10	12	9	11	9	11	9	10	8	9	8	N/A	N/A	N/A	N/A
Collector	12	9	11	9	10	9	10	9	9	8	8	7	N/A	N/A	N/A	N/A
Arterial	N/A	N/A	9	9	8	8	8	8	N/A	7	N/A	7	N/A	6	N/A	6

R = Residential, C/I = Commercial/Industrial

Note: For federal-aid projects, proposed design values that do not meet the “Acceptable” table may require design exceptions. Design exceptions will be considered on a project-by-project basis and must have concurrence of the Iowa DOT when applicable. For non-federal aid projects, the designer should contact the Jurisdiction to determine what level of documentation, if any, is required prior to utilizing design values that do not meet the “Acceptable” table.

Table 5C-1.02 Footnotes:

- <sup>1</sup> Number of traffic lanes, turn lanes, intersection configuration, etc. should be designed to provide the specified LOS at the design year ADT.
- <sup>2</sup> Width shown is for through lanes and turn lanes.
- <sup>3</sup> Bridge width is measured as the clear width between curbs or railings. Minimum bridge width is based upon the width of the traveled way (lane widths) plus 3 feet clearance on each side; but no less than the curb-face to curb-face width of the approaching roadway. Minimum bridge widths do not include medians, turn lanes, parking, or sidewalks. At least one sidewalk should be extended across the bridge.
- <sup>4</sup> The values shown are the clear width across the bridge between curbs or railings. Values are based upon the width of the traveled way (lane width) and include a 1 foot and 2 foot offset on each side for collectors and arterials respectively. Values do not include medians, turn lanes, parking, or sidewalks. In no case should the minimum clear width across the bridge be less than the width of the traveled way of the approach road.
- <sup>5</sup> Vertical clearance includes a 0.5 foot allowance for future resurfacing. Vertical clearance of 14.5 feet on arterials is allowed only if an alternate route with 16 feet of clearance is available.
- <sup>6</sup> Object setback does not apply to mailboxes constructed and installed according to US Postal Service regulations, including breakaway supports.
- <sup>7</sup> Values shown are measured from the edge of the traveled way to the back of curb. Curb offset is not required for turn lanes. On roadways with an anticipated posted speed of 45 mph or greater, mountable curbs are required. For pavements with gutterline jointing, the curb offset should be equal to or greater than the distance between the back of curb and longitudinal gutterline joint.
- <sup>8</sup> At locations where a 1.5 foot curb offset is used, an alternative intake boxout, with the intake set back a minimum of 6 inches from the curb line, must be used to prevent intake grates from encroaching into the traveled way.
- <sup>9</sup> Some jurisdictions allow parking on both sides of the street. When this occurs, each jurisdiction will set their own standards to allow for proper clearances, including passage of large emergency vehicles.
- <sup>10</sup> For low volume residential streets, two free flowing lanes are not required and a 26 foot roadway may be used where parking is allowed on one side only. For higher volume residential streets, which require two continuously free flowing traffic lanes, a 31foot roadway should be used.
- <sup>11</sup> Some minimum roadway widths have been increased to match standard roadway widths. Unless approved by Jurisdiction, all two lane roadways must comply with standard widths of 26, 31, 34, or 37 feet.
- <sup>12</sup> Median width is measured between the edges of the traveled way of the inside lanes and includes the curb offset on each side of the median. Values include a left turn lane with a 6 foot raised median as required to accommodate a pedestrian access route (refer to [Chapter 12](#)) through the median (crosswalk cut through). At locations where a crosswalk does not cut through the median, the widths shown can be reduced by 2 feet to provide a 4 foot raised median.
- <sup>13</sup> The use of 3:1 foreslopes is allowed, as shown, but may require a wider clear zone as slopes steeper than 4:1 are not considered recoverable by errant vehicles.
- <sup>14</sup> It is preferred to select a design speed that is at least 5 mph greater than the anticipated posted speed limit of the roadway. Selecting a design speed equal to the posted speed limit may also be acceptable and should be evaluated on a project by project basis, subject to approval of the Engineer
- <sup>15</sup> Values for low design speed (<50 mph) assume no removal of crown (i.e. negative 2% superelevation on outside of curve). According to the AASHTO Green Book (Table 3-1 and 3-13b) for low volume roadways with 10 or less units beyond the curve and projected traffic volumes of less than 100 vehicles per day beyond the curve, the horizontal curve radius may be a minimum of 107 feet if at least 115 feet of stopping sight distance is provided or the radius may be a minimum of 50 feet if at least 80 feet of stopping sight distance is available. Radii for design speeds of 50 mph or greater are based upon a superelevation rate of 6%. For radii corresponding to other superelevation rates, refer to the AASHTO’s “Green Book.”
- <sup>16</sup> Assumes stopping sight distance with 2 foot high object.
- <sup>17</sup> Use only if roadway has continuous overhead lighting.
- <sup>18</sup> A typical minimum grade is 0.5%, but a grade of 0.4% may be used in isolated areas where the pavement is accurately crowned and supported on firm subgrade.
- <sup>19</sup> Maximum gradient may be steepened by 2% for short distances and for one way downgrades.

**Table 5C-1.03:** Preferred Clear Zone Distances for Rural and Urban Roadways

Design Speed mph	Design Traffic ADT	Foreslope			Backslope or Parking		
		6:1 or flatter	5:1 to 4:1	3:1	6:1 or flatter	5:1 to 4:1	3:1
In feet from edge of traveled way							
Urban 40 or less	All	For low-speed urban roadways, refer to 5C-1, C, 1.					
Rural 40 or less	Under 750	10	10	*	10	10	10
	750 to 1,500	12	14	*	12	12	12
	1,500 to 6,000	14	16	*	14	14	14
	Over 6,000	16	18	*	16	16	16
Rural and Urban 45 to 50	Under 750	12	14	*	12	10	10
	750 to 1,500	16	20	*	16	14	12
	1,500 to 6,000	18	26	*	18	16	14
	Over 6,000	22	28	*	22	20	16
Rural and Urban 55	Under 750	14	18	*	12	12	10
	750 to 1,500	18	24	*	18	16	12
	1,500 to 6,000	22	30	*	22	18	16
	Over 6,000	24	32	*	24	22	18
Rural and Urban 60	Under 750	18	24	*	16	14	12
	750 to 1,500	24	32	*	22	18	14
	1,500 to 6,000	30	40	*	26	22	18
	Over 6,000	32	44	*	28	26	22

Source: Adapted from the *Roadside Design Guide*, 2006**Table 5C-1.04:** Acceptable Clear Zone Distances for Rural and Urban Roadways

Design Speed mph	Design Traffic ADT	Foreslope			Backslope or Parking		
		6:1 or flatter	5:1 to 4:1	3:1	6:1 or flatter	5:1 to 4:1	3:1
In feet from edge of traveled way							
Urban 40 or less	All	For low-speed urban roadways, refer to 5C-1, C, 1.					
Rural 40 or less	Under 750	7	7	*	7	7	7
	750 to 1,500	10	12	*	10	10	10
	1,500 to 6,000	12	14	*	12	12	12
	Over 6,000	14	16	*	14	14	14
Rural and Urban 45 to 50	Under 750	10	12	*	10	8	8
	750 to 1,500	14	16	*	14	12	10
	1,500 to 6,000	16	20	*	16	14	12
	Over 6,000	20	24	*	20	18	14
Rural and Urban 55	Under 750	12	14	*	10	10	8
	750 to 1,500	16	20	*	16	14	10
	1,500 to 6,000	20	24	*	20	16	14
	Over 6,000	22	26	*	22	20	16
Rural and Urban 60	Under 750	16	20	*	14	12	10
	750 to 1,500	20	26	*	20	16	12
	1,500 to 6,000	26	32	*	24	18	14
	Over 6,000	30	36	*	26	24	20

Source: Adapted from the *Roadside Design Guide*, 2006

- \* Foreslopes steeper than 4:1 are considered traversable, but not recoverable. An errant vehicle can safely travel across a 3:1 slope, but it is unlikely the driver would recover control of the vehicle before reaching the bottom of the slope; therefore, fixed objects should not be present on these slopes or at the toe of these slopes.

- 1. Clear Zone for Low-speed (40 mph or less Design Speed) Urban Roadways with Curbs:** A minimum clear zone behind the back of curb of 6 feet (preferred) or 4 feet (acceptable) should be provided regardless of roadway classification. Clear zone requirements also apply along medians of divided roadways (Maze, 2008; AASHTO *Roadside Design Guide*, 4<sup>th</sup> Edition).

## D. References

American Association of State Highway and Transportation Officials (AASHTO) *Roadside Design Guide*. 4<sup>th</sup> Edition. Washington, DC. 2011.

Maze T. Hawkins N. et al. Clear Zone - A Synthesis of Practice and an Evaluation of the Benefits of Meeting the 10ft Clear Zone Goal on Urban Streets. Center for Transportation Research and Education. Iowa State University. 2008.